PCT/AU2004/000943

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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003903632 for a patent by QNI TECHNOLOGY PTY LTD as filed on 14 July 2003.

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Twenty-third day of July 2004

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Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: **PROCESS FOR RECOVERY OF NICKEL AND COBALT BY HEAP LEACHING OF LOW GRADE NICKEL OR COBALT CONTAINING MATERIAL**

Applicant: **QNI TECHNOLOGY PTY LTD**

The invention is described in the following statement:

PROCESS FOR RECOVERY OF NICKEL AND COBALT BY HEAP LEACHING OF LOW GRADE NICKEL OR COBALT CONTAINING MATERIAL

Field of the Invention

In general, the present invention relates to a method for improving the recovery of nickel and cobalt from laterite ores. In particular, the present invention provides an improved hydrometallurgical method of extraction of nickel and cobalt from nickel and cobalt containing laterite ores by pressure leaching or atmospheric agitation leaching of the upgraded limonite and saprolite fractions of the ores, and by heap leaching of under grade limonite and saprolite material that is normally rejected during the beneficiation of the ores.

Background of the Invention

Laterite nickel and cobalt ore deposits generally contain oxidic type ores, limonites, and silicate type ores, saprolites, in the same deposits. The higher nickel content saprolites tend to be treated by a pyrometallurgical process involving roasting and electrical smelting techniques to produce ferro nickel. The power requirements and high iron to nickel ore ratio for the lower nickel content limonite and limonite/saprolite blends make this processing route too expensive, and these ores are normally commercially treated by a combination of pyrometallurgical and hydrometallurgical processes, such as the High Pressure Acid Leach (HPAL) process or the Caron reduction roast - ammonium carbonate leach process.

As alternatives to HPAL, which uses expensive high pressure equipment, atmospheric pressure agitation acid leach processes, and processes combining HPAL for the limonite fraction of an ore followed by atmospheric acid leaching of the saprolite fraction have been disclosed. In order to reduce the size of leaching reactors, high grade limonite and saprolite are preferred for these processes. This leads to rejecting the low grade ore as waste.

The exploitation of many of the lower nickel content ores by the above processes generally requires whole ore processing as there is no effective method to beneficiate the ore. This has the disadvantage that the mineralogical fractions of the ore which may contain lower metal values effectively dilute the total treated ore quality and increase recovery costs.

Even where the laterite ore is amenable to some form of beneficiation, where the upgraded ore is processed by one of the previously discussed methods, the reject fraction containing low nickel and cobalt grades is normally discarded as uneconomic to process by the above methods, thus losing the value of the nickel and cobalt contained in the rejects.

Heap leaching is a conventional method of economically extracting metals from low grade ores and has been successfully used to recover materials such as copper, gold, uranium and silver. Generally it involves piling raw ore directly from ore deposits into heaps that vary in height. The leaching solution is introduced onto the top of the heap to percolate down through the heap. The effluent liquor is drained from the base of the heap and passes to a processing plant where the metal values are recovered.

One problem hindering the heap leaching of nickel and cobalt containing laterite ores is the substantial clay component of such ores. The type of clay content is dependent on the parent rock and the physico chemical environment of the clay formation, but most clays have a detrimental effect on the percolation of the leach solution through the ore.

It has been reported that when laterite is piled dry, the leach solution percolation was poor to impossible. Because of the poor permeability, a low irrigation rate is necessary to allow the solution to leach the nickel and cobalt, thus requiring a leach time that is uneconomical.

US Patent. No. 5,571,308 (BHP Minerals International, Inc) describes a process for heap leaching of high magnesium containing laterite ore such as saprolite . The patent points out that the clay type saprolite exhibits poor

permeability, and as a solution to this, pelletisation of the ore is necessary to ensure distribution of the leach solution through the heap.

US patent no. 6,312,500 (BHP Minerals International, Inc) also describes a process for heap leaching of laterites to recover nickel, which is particularly effective for ores that have a significant clay component(greater than 10% by weight). The process includes sizing of the ore where necessary, forming pellets by contacting the ore with a lixivant, and agglomerating. The pellets are formed into a heap and leached with sulphuric acid to extract the metal values.

Both the above patents identify the need to pelletise the whole ore feed to obtain the permeability of the heap necessary for successful heap leaching.

The above discussion of documents, articles and the like is included in the specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date.

The present invention aims to overcome or at least alleviate one or more of the difficulties associated with the prior art.

Summary of the Invention

In general, the present invention provides a method for improving the recovery of nickel and cobalt from laterite ores, the method including the steps of:

a) beneficiating the ore to separate it into an upgraded ore fraction and a course and siliceous beneficiation rejects fraction free from fines and clay materials;

b) separately processing the upgraded ore fraction for the recovery of nickel and cobalt; and.

c) subjecting the beneficiation rejects fraction to a heap leach process with an acid supplemented solution to create a heap leachate for further nickel and cobalt recovery processing.

In general, the process forms part of an overall process for the recovery of nickel and cobalt where nickel and cobalt are recovered from the beneficiated upgraded ore fraction by high pressure acid leaching (HPAL) or atmospheric pressure agitation leaching to extract the nickel and cobalt. A particular feature of the process of this invention is that the heap leachate from the rejects fraction (or low grade ore fraction) can be blended with the leach solution from the acid leaching process of the upgraded ore fraction, increasing the yield of nickel and cobalt recovered from the whole laterite ore. The nickel and cobalt may be recovered from the blended leachate from both the heap leach process and the leach solution from the upgraded ore fraction by conventional methods such as precipitation as a mixed hydroxide, or treatment by solvent extraction or ion exchange processes to separate the nickel and cobalt.

The Inventors have surprisingly found that where the beneficiation rejects are free of fines and clay materials, that the remaining siliceous beneficiation rejects have a high permeability which makes it suitable for heap leaching without the pelletisation needed in treating the clay type ores reported in US patent 5,571,308 and 6,312,500. The high permeability allows a relatively rapid leaching rate with approximately 50% extraction of nickel in 14 days in static tests. Extraction of both nickel and cobalt from the beneficiation rejects is relatively high with a low acid consumption.

In a particularly beneficial aspect of the present invention the resultant leach liquor from the heap leaching of the beneficiation rejects can be processed together with the leach liquor from the acid leaching of the higher grade ore fraction. They can be processed separately if required, however

combined processing leads to efficiencies in metal recovery and reduction in equipment requirements. Existing technologies can be used for treatment of the pregnant leach liquors for nickel and cobalt recovery. For example, this can be achieved via selective precipitation (i.e. sulphide precipitation, or mixed hydroxide precipitation), solvent extraction or ion exchange.

In another embodiment, the beneficiation rejects fraction may be produced from the separate beneficiation of the limonite and saprolite fractions of the laterite ore, and the beneficiation rejects each formed into separate heaps of limonite and saprolite reject materials. Forming separate heaps has the advantage that leaching the limonite provides for maximum nickel recovery and the saprolite leaching provides for iron removal. The heap leachate from the separated heaps may still be blended with the leach solution from the acid leaching of the upgraded ore fraction to provide further efficiencies in metal recovery.

In yet a further embodiment, the pregnant solution from the limonite rejects heap may be passed through the saprolite rejects heap, which will assist in neutralising the solution and precipitating some of the dissolved iron, while at the same time recovering more of the nickel and cobalt from the rejects heap.

The acid supplemental solution may comprise a solution of acidified water, seawater or underground brine, or may be the acidified waste solution from the acid leach of the upgraded ore fraction.

The low metal grades of nickel and cobalt, in the beneficiation rejects fraction may have approximately 0.3% to 0.7% nickel and 0.01% to 0.03% cobalt. This rejects fraction would normally be uneconomic to process by any of the conventional routes. However, removal of the clays and fines from the rejects fraction transforms what would previously have been a waste into an economically processable material by application of the heap leach process to this material.

It is particularly attractive where the upgraded ore fraction produced by the beneficiation step is processed in parallel by the HPAL or atmospheric pressure leach processes, or any combination of these processes. In this case the nickel and cobalt acidic solution from both the upgraded laterite ore leaching and the heap leaching of the rejects fraction may be processed together by the same route to produce the required nickel and cobalt products, economising on equipment and capital.

Description of the Drawing

The description of the drawing is intended to be illustrative of the invention, and it is not intended that the invention is limited to the specific features described. Figure 1 illustrates the process flow diagram of the invention. This shows the preliminary treatment of the laterite ore by first undergoing course size reduction in a crusher and then removal of the fines and/or clay, which is typically done by washing, for example hydraulically washing as part of the beneficiation process. The course material (the beneficiation rejects fraction), absent of the fines and/or clay materials, is then subjected to heap leaching with acid to provide a pregnant leachate solution. The upgraded laterite fraction together with the fines material, is sent for nickel recovery treatment by pressure acid leaching or atmospheric leaching. The pregnant leachate solution from this process is combined with the leachate solution from the heap leach process for nickel and cobalt recovery by standard means.

Examples

Example 1

Tests were carried out on a dry laterite ore, characterised by containing a large amount of barren quartz and the relative absence of smectitic clays. Nickel in the laterite is associated predominantly with the intrinsically fine goethite, which is easily separated from the harder, coarser quartz material. The goethite/limonite zone and saprolite zones are characterised by the

occurrence of abundant siliceous net-veins and box-works, which impart properties conducive to beneficiation.

The beneficiation process involves the physical separation (scrubbing, screening and classification) of the high-grade fine fraction of the ore (product) from the coarse low-grade fraction (reject). Nickel is predominantly associated with very fine-grained iron hydroxide minerals in the limonite zone and very fine-grained weathered nickel-magnesium silicates as well as the very fine-grained iron hydroxide minerals in the saprolite zone. These nickel-bearing minerals are softer than and encapsulated by, the indurated gangue minerals that form a hard cellular vein network. The level of development of this network is greater in the limonite, where weathering has reached a higher level of completion and beneficiation performance is consequently enhanced.

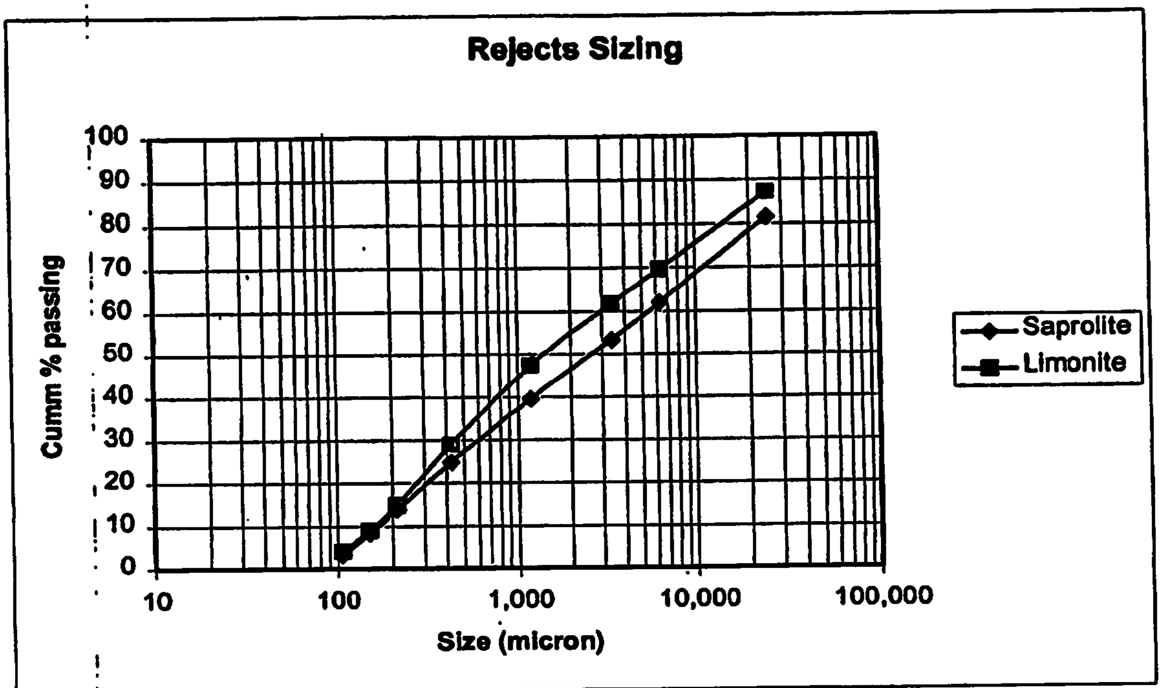
The samples that have undergone test work have been prepared from individual 1 metre intervals taken from a series of large diameter (~900 mm) bulk drill holes which penetrated up to approximately 50 m into the ore bodies. A range of blended ore types and single "material" types have been tested, from limonitic through to saprolitic. The samples were also chosen to cover a spatial distribution across the ore bodies, to allow a better understanding of the beneficiation characteristics of a wide range of material types.

Typically, for the limonite fraction, 57.5% of the nickel and 45.8% of the cobalt are recovered by the drum scrubber beneficiation process from the laterite ore into the high grade (upgraded) laterite. For the saprolite fraction the numbers are 57.3% and 48.9% respectively.

The beneficiation rejects are predominately siliceous from the limonite ores and a mixture of silica and serpentenite from the saprolite ores. The beneficiation process strips away all material less than 75μm leaving a sandy reject with a D_{50} of 1.5mm - 3mm as shown in Figure 2. Approximately 10% of the material is greater than 125mm but 100% less than 250mm. This material

is ideal for heap leach due to the absence of fines and with a relatively tight size distribution (50% of the material lies between 0.2 and 6.3mm). This size distribution allows both good flow characteristics without the channelling issues associated with large impervious (either clay or rock) sections.

Figure 2 Rejects Size Distribution



TESTWORK

Two size fractions of the rejects (low grade ore) fraction were produced during the beneficiation process and were tested as follows:

The testing took the form of cylinder tests saturated with either 100 kg/t or 200 kg/t of sulphuric acid on 75µm to 1mm reject material and 1mm to 6mm reject material from the pilot plant operation. The full analysis of the two reject material samples is given in Table 1.

1000 mL measuring cylinders were filled to approximately the 800 mL mark with a known weight of sample and a sulphuric acid solution equating to

either of the two concentrations above was added. Each cylinder was rotated twice daily (at the start and finish of day shift) to ensure mixing and no diffusion controlled reactions, thus simulating flow through a heap.

Table 1 Reject Analysis

	Feed %	SG g/cm^3	Ni %	Co %	Al %	Ca %	Fe %	Mg %	Mn %	SiO2 %	CO_3 %
1-6mm Reject Material	17.9	2.66	0.49	0.021	0.3	0.5	8.5	1.1	0.09	79.0	1.9
75µm-1mm Reject Material	17.1	2.86	0.52	0.030	0.3	0.8	8.2	1.1	0.12	79.1	3.1

The change in acid concentration and nickel and cobalt extraction, over a 14 day period, were monitored with a full solids/liquids balance of elements determined at the end of the period.

Typically acid consumption was approx. 100 kg/t of solids and, as can be seen from Figures 3 & 4, nickel extraction was greater than 50% while cobalt extraction was 55% for the finer size (75µm-1mm reject material) and 35% for the coarser size(1-6mm reject material).

In both cases the extraction of both nickel and cobalt was still increasing after 14 days. The nickel and cobalt tenor of the pregnant solutions is high, reflecting the good extraction levels achieved. These along with the major impurity levels are shown in Table 2.

Table 2 Elemental distribution of Leach Products in the pregnant solutions

Sample	Test Product	Ni (ppm)	Co (ppm)	Fe (%)	Mg (ppm)	Al (ppm)	Ca (ppm)	Mn (ppm)
75µm-1mm Reject Material	Solution	4965	330	7.85	13625	1260	280	1125
	Residue	2455	135	4.84	4790	2370	1280	392
1-6mm Reject Material	Solution	4630	140	6.65	9850	1200	273	648
	Residue	2630	130	5.65	5415	2095	2775	438

Solution concentrations approaching 5 g/L Ni are comparable with those obtained from the HPAL process or the atmospheric leaching process and this solution would be directly applicable to feed to a solution purification and hydroxide precipitation circuit.

With remaining metal values of 0.25% Ni and 0.013% Co in the heap leach rejects, this represent 75% and 70% nickel and cobalt recovery respectively after taking into account the original beneficiation recovery of around 57.5 and 45.8% respectively, and is a major improvement in overall recovered metal from the ore.

Figure 3 Cylinder Leach Test 75μm –1mm Reject Fraction

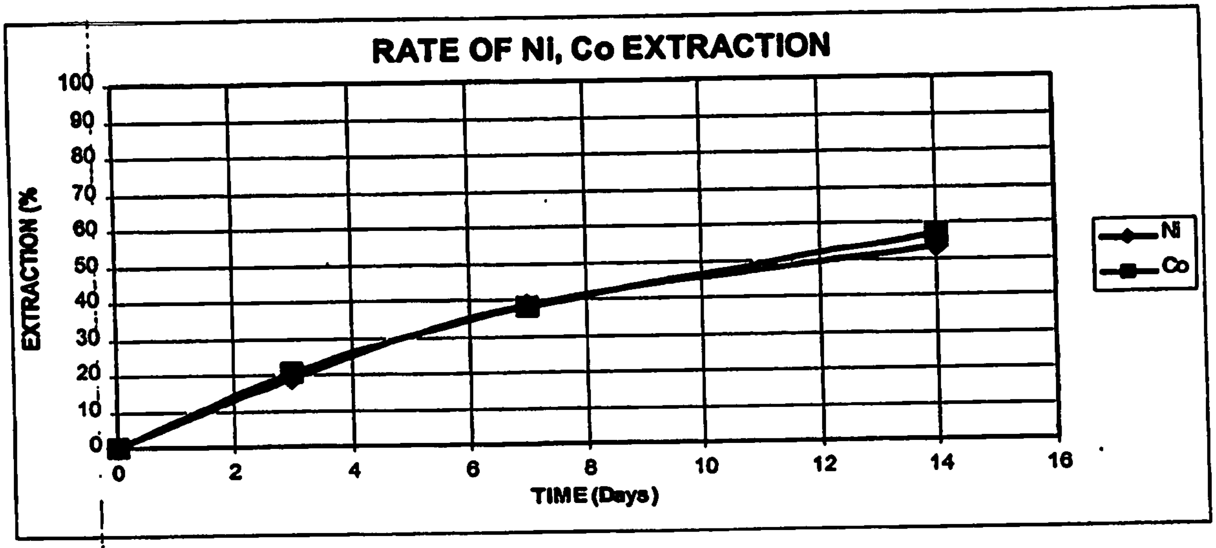
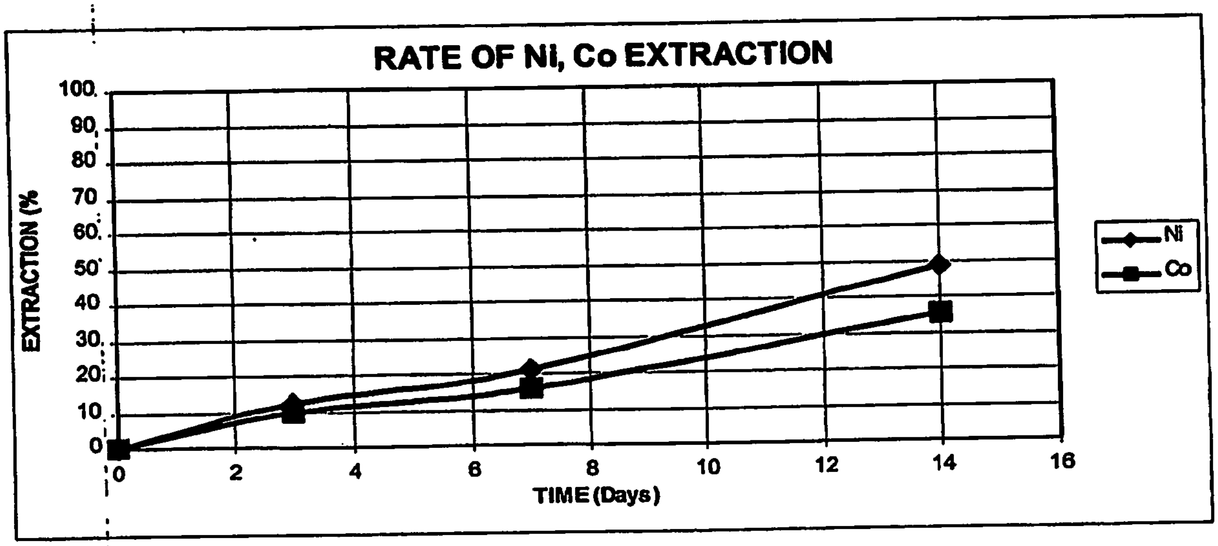


Figure 4 Cylinder Leach Test 1mm –6mm Reject Fraction



The above description is intended to be illustrative of the preferred embodiment of the present invention. It should be understood by those skilled in the art, that many variations or alterations may be made without departing from the spirit of the invention.

Finally it is to be understood that various other modifications and/or alterations may be made without departing from the spirit of the present invention as outlined herein.

DATED: 14 July, 2003
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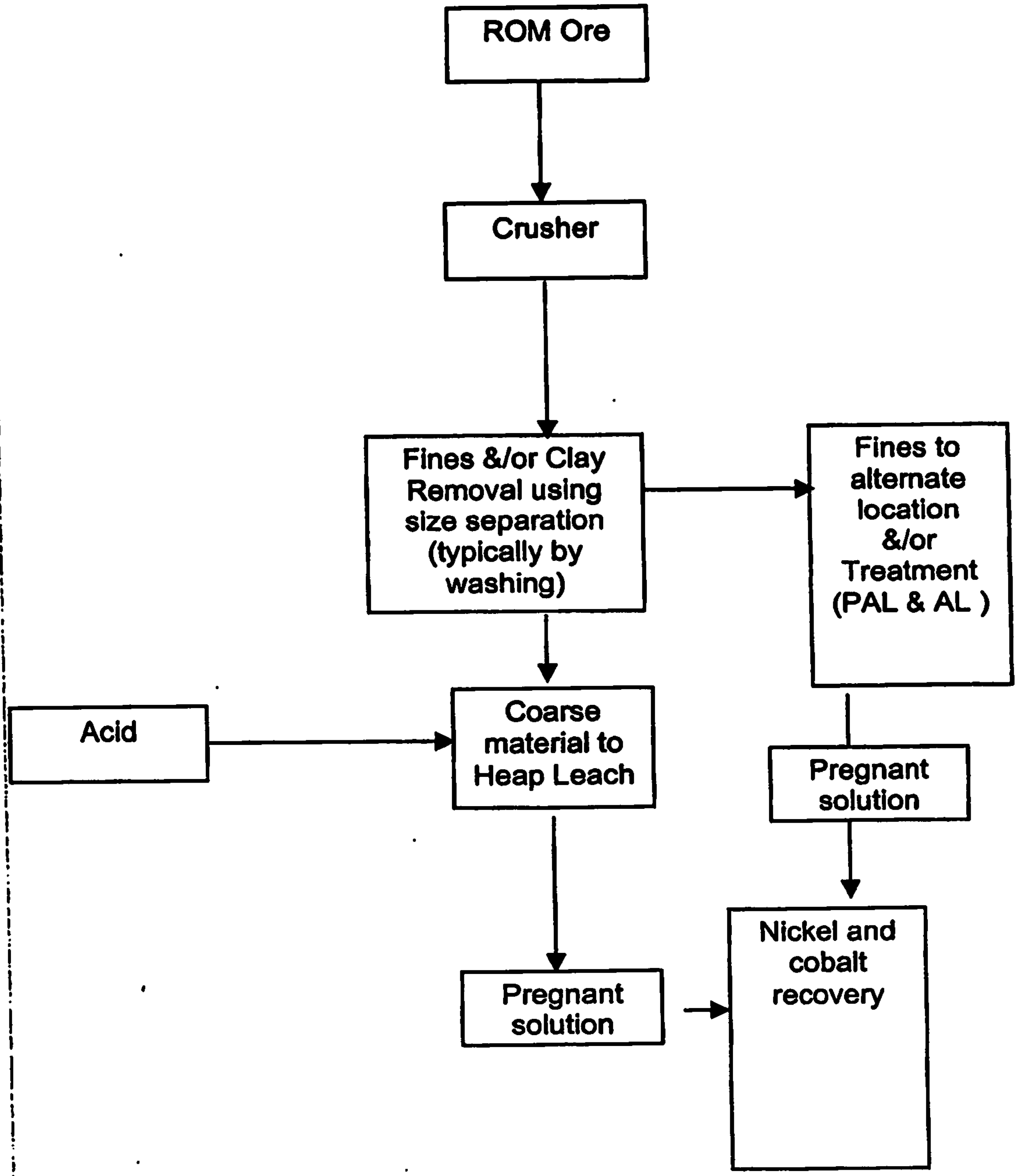
ROM Ore
Crusher
Fines &/or Clay Removal using size separation (typically by washing)
Fines to alternate location &/or Treatment (PAL & AL)
Acid
Coarse material to Heap Leach
Pregnant solution
Nickel and cobalt recovery
Pregnant solution

Figure 1